PB90-234220

Final Best Demonstrated Available Technology (BDAT) Background Document for Chromium Wastes D007 and U032 Volume 22

Versar, Inc., Springfield, VA

Prepared for:

Environmental Protection Agency, Washington, DC

May 90

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/530-SW-90- 059V	2.	3. PB90-234220
4. Title and Subtitle FINAL BDAT BACKGROUND DOCUMENT FOR CHROMIUM WASTES D007 and U032			5. Report Date May 1990 6.
7. Author(s) Rosengrant/ Labiosa/OSW			8. Performing Organization Rept. No
9. Performing Organization Name and Address U.S. EPA Office of Solid Waste 401 M. Street SW Washington, DC 20460			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) 68-W9-0068 (G)
12. Sponsoring Organization Name and Address Versar, Inc.			13. Type of Report & Period Covered Background Document - 5/90 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This background document provides the Agency's technical support and rationale for the development of treatment standards for the constituents to be regulated for the above-mentioned wastes.

Section 2 through 6 presents waste-specific information for the D007 wastes. Section 7 discusses an associated chromium-containing U-code waste (U032 - calcium chromate) and details the development of the treatment standards for this waste.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
RELEASE UNLIMITED	UNCLASSIFIED	0
	20. Security Class (This Page) UNCLASSIFIED	22. Price 0

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

EPA/530-SW-90-054V

PB90-234220

FINAL
BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR

CHROMIUM WASTES
D007 AND U032

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May 1990

ACKNOWLEDGMENTS

This document was prepared for the U.S. Environmental Protection Agency, Office of Solid Waste, by Versar Inc. under Contract No. 68-W9-0068. Mr. Larry Rosengrant, Chief, Treatment Technology Section, Waste Treatment Branch, served as the EPA Program Manager during the preparation of this document. The technical project officer for the waste was Mr. Jose Labiosa. Mr. Steven Silverman served as legal advisor.

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1. INTRODUCTION AND SUMMARY

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act (RCRA), enacted as a part of the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, the Environmental Protection Agency (EPA) is promulgating treatment standards based on the best demonstrated available technology (BDAT) for the characteristic chromium-containing waste identified in 40 CFR 261.24 as D007 and for the commercial chemical product waste identified in 40 CFR 261.33 as U032 - calcium chromate. Compliance with the final BDAT treatment standards is a prerequisite for the placement of these wastes in units designated as land disposal units according to 40 CFR Part 268. The effective date of final promulgated treatment standards for these wastes will be August 8, 1990.

This background document provides the Agency's technical support and rationale for the development of treatment standards for the constituents to be regulated for the above-mentioned chromium-containing wastes. Sections 2 through 6 present waste-specific information for the D007 wastes. Section 2 describes the industries affected by regulation of these wastes, explains the processes generating these wastes, and presents available waste characterization data. Section 3 specifies the applicable and demonstrated treatment technologies for these wastes. Section 4 contains performance data for the demonstrated technologies, and Section 5 contains analyses of these performance data to determine BDAT for each waste. Section 6 contains the determination of BDAT treatment standards for the regulated constituent (chromium). Section 7 discusses an associated chromium-containing U-code waste (U032 - calcium chromate) and details the development of the treatment standards for this waste.

The BDAT program and promulgated methodology are more thoroughly described in two additional documents: Methodology for Developing BDAT

Treatment Standards (USEPA 1989a) and Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (USEPA 1988a). The petition process to be followed in requesting a variance from the BDAT treatment standards is discussed in the methodology document.

Standards are being promulgated for the wastewater and nonwastewater forms of these wastes. For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Waste not meeting this definition must comply with the treatment standards for nonwastewaters.

The treatment standards promulgated for U032 are transferred from the treatment of K062 wastewaters and nonwastewaters. The treatment standards for K062 were based on treatment of a mixture of K062 and other EP-toxic wastewaters treated by chromium reduction followed by chemical precipitation, settling, filtering, and dewatering of solids. EPA has no information to indicate that any of the constituents present in U032 are likely to interfere with the reduction treatment of hexavalent chromium achieved in the treated mixture of K062 and EP-toxic wastewaters.

For D007 wastes, EPA proposed treatment standards based on the same performance data supporting U032 treatment standards (i.e., K062 data). EPA requested comments on the achievability of the proposed D007 nonwastewater standard of 0.094 mg/l chromium (total), noting that alternative performance data based on the stabilization of F006 nonwastewaters could be used to support promulgation of a treatment

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* The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, the quantity of total suspended solids is measured by Method 209c (Total Suspended Solids Dried at 103°C to 105°C) in Standard Methods for the Examination of Water and Wastewater, 15th Edition (APHA, AWWA, and WPCF 1985).

standard of 5.2 mg/l. The vast majority of comments on the proposed D007 standard stated that the diversity of D007 wastes generated from different manufacturing processes could not possibly be represented by the K062 performance data and that the proposed treatment standard of 0.094 mg/l could not possibly be achieved on a routine basis for all nonwastewater forms of D007 wastes. Several commenters submitted treatment data to show that the proposed treatment standard, i.e., 0.094 mg/l, transferred from K062 data, was unachievable.

EPA reviewed all of the treatment performance data submitted to the Agency during the comment period and calculated a treatment standard from each of these data sets (see Appendix A). The Agency received 10 data sets for treatment of various D007 wastes discussed further in Section 4 of this document. The Agency examined the quality and completeness of these data for the nonwastewater residues. The Agency determined that eight were deficient in information and therefore failed to meet the BDAT criteria for data quality. Therefore, the Agency determined that these data could not support the development of a treatment standard for D007 wastes. The deficiencies of many of these data were as follows: no untreated waste concentrations corresponding to treated waste concentrations, no waste source descriptions, no binder-to-waste ratios for stabilization, no treatment operating/design information, no treatment step for hexavalent chromium reduction, and/or no quality assurance and quality control (QA/QC) information.

Two data sets (one from CyanoKem and one from the Hazardous Waste Treatment Council) have some deficiencies in meeting the BDAT criteria, but they represent the same or similar BDAT train used to treat K062 or F006 and are more complete than other data submitted during the comment period. While neither of these two data sets is as sound as the data for F006 or K062, these data indicate that the K062 nonwastewater standard of

0.092 mg/l chromium (TCLP) is not generally achievable. Treatment standards calculated using these data would result in a D007 nonwastewater standard of 0.74 mg/l chromium (total) for the TCLP leachate (based on ten data points from the HWTC's data having corresponding untreated and treated TCLP concentrations) and 0.86 mg/l chromium (total) for the TCLP leachate (based on CyanoKem's data).

In considering the usefulness of the two data sets that are more complete than the others (i.e., the data from CyanoKem and from the Hazardous Waste Treatment Council), the Agency examined what the treatment standards would have been if they had been derived from these data. One data set (from CyanoKem) would have resulted in a standard of 0.86 mg/l, and another data set (using only ten of the more complete data points from the HWTC) would have resulted in a standard of 0.74 mg/l. (Note: Both are based on TCLP analysis.)

However, the HWTC data contained an additional 32 incomplete treatment data points (no untreated TCLP analyses), many of which could not meet the 0.86 mg/l or the 0.74 mg/l treatment standards. Assuming that these previously rejected 32 data points represent valid treatment, the Agency decided that both the 0.86 mg/l and the 0.74 mg/l standards calculated on just 20 data points were not achievable on a routine basis. The Agency found that it was difficult to ascertain (per treatment facility) the mixing ratios of waste volumes that were received from each of the different industries. While the data indicated that some wastes contained very high concentrations of chromium, the lack of information on mixing ratios and feed rates made it difficult to assess the true effectiveness of treatment (i.e., the Agency could not determine the chromium concentration of mixed D007 wastes just prior to treatment).

The Agency points out that the data from CyanoKem represented primarily treatment of liquid waste (some with very high concentrations

of chromium). Some of the sludges generated from this process did not require further treatment (i.e., stabilization). This same situation occurred in generating the promulgated treatment standards for K062 wastes, in that the wastewater treatment process employed for treating the combined K062/D007 wastes was effective enough that the treatment sludges were not characteristic for chromium and did not require any further stabilization (thus, the derivation of the 0.094 mg/l proposed standard for D007 wastes). While CyanoKem's data clearly indicated that the proposed 0.094 mg/l standard could not be achieved, thus implying that their combined D007 wastes were more difficult to treat, their data did not represent wastes similar to those represented by the HWTC data, which were composed primarily of sludge stabilization data.

The Agency then decided to examine what the treatment standard would be based on all of the data from CyanoKem and the HWTC (i.e., using all 52 data points, except for one from the HWTC data that the Agency believes clearly represented an outlier). In doing so, it significantly increased the number of data points and also represented a greater variety of wastes from a greater cross-section of industries. Despite all of this, the Agency took a conservative approach and assumed that proper and effective treatment had occurred for all of the data.

The resultant standard using these combined data was 4.3 mg/l based on TCLP. While the combined data are technically "weak" because of various deficiencies in BDAT information, the combined two data sets do reflect the treatment of the widest variety of wastes most similar to that expected for all D007 wastes. The Agency contemplated promulgating the 4.3 mg/l standard as an alternative to the 5.2 mg/l standard from F006; however, this level is so close to the 5.0 mg/l characteristic level that the Agency does not believe the significant regulatory disruptions and uncertainties inherent in applying direct Part 268 regulation to Subtitle D facilities is warranted.

The Agency notes that the 5.2 mg/l F006 standard was also generated by the commercial treatment industry and that further combination of the F006 data with the commenters' data would probably result in a standard even closer to the characteristic level of 5.0 mg/l. As it is, a measurement of 4.3 mg/l by the TCLP test is approximately 86 percent of the 5.0 mg/l characteristic level and within the analytical error that may be expected for such an analysis.

As a result of these comments and data, EPA is withdrawing the proposed treatment standards for D007 wastes, i.e., the transfer from F006 and K062. While the Agency contemplated promulgating the 5.2 mg/l F006 standard, the Agency notes that if the F006 data were included with the commenter's data, then the combined data set would produce a treatment standard even closer to the characteristic level than the 4.3 mg/l standard calculated using the commenters' data. The treatment standards promulgated today, therefore, are set at the characteristic level of 5.0 mg/l chromium (total, as measured by TCLP) for nonwastewaters and 5.0 mg/l (total concentration) for wastewaters. While the majority of commenters support this approach from a policy standpoint, the Agency is convinced that the available data submitted by them clearly indicate the validity of the achievability of this standard.

Some D007 nonwastewaters are generated in the form of refractory bricks containing percent levels of hexavalent chromium. The Agency has identified one facility, i.e., INMETCO, that is recovering chromium using a high-temperature thermal recovery process. The bricks are crushed and recycled as feedstock along with other raw materials in the manufacture of refractory bricks or metal alloys. This recovery technology is currently used for bricks that contain up to 20 percent chromium, but INMETCO believes the technology can treat bricks containing up to 40 percent chromium. However, INMETCO also indicated that there are upper limits on the amount of phosphorus present in the bricks that would lower the quality of the product produced from the recovered chrome.

EPA has determined that this thermal recovery process is an alternative treatment for some forms of these D007 refractory bricks. However, the Agency is currently uncertain to what extent this thermal recovery technology is demonstrated for all of the various types of refractory bricks currently being land disposed. Thus, the Agency is not establishing high temperature thermal recovery as a treatment standard for these D007 wastes, but is not precluded from doing so in the future. At the same time, facilities are not precluded from using this technology for these type of wastes.

Some commenters submitted data on the stabilization of these spent refractory bricks. These data are one of the eight data sets rejected by the Agency for reasons outlined above. These data consist of analysis on two TCLP extracts of crushed refractory brick that were subjected to two different stabilization technologies. One technology utilized cement as a stabilization reagent and achieved a treated TCLP level for chromium of 70 mg/l. The other technology was a glassification process that achieved a treated TCLP level for chromium of 110 mg/l. While these performance data are incomplete, they appear to indicate that chromium bricks could be more difficult to treat than the other chromium-containing wastes tested by EPA (K062 or F006) or, more likely, that stabilization of chromium bricks may need to be preceded by a hexavalent chromium reduction step. Congress, in fact, contemplated that hexavalent chromium would be reduced to the maximum extent possible before prohibited wastes are land disposed.

PQ Corporation submitted data on the stabilization of these spent refractory bricks. These data are one of the eight data sets rejected by the Agency for reasons outlined above. These data consist of analysis of two TCLP extracts of crushed refractory brick that were subjected to two different stabilization technologies. One technology utilized cement as

a stabilization reagent and achieved a treated TCLP level for chromium of 70 mg/l. The other technology was a glassification process that achieved a treated TCLP level for chromium of 110 mg/l. While these performance data are incomplete, they appear to indicate that chromium bricks could be more difficult to treat than the other chromium-containing wastes tested by EPA (K062 and F006) or, more likely, that stabilization of chromium bricks may need to be preceded by a hexavalent chromium reduction step. Congress, in fact, contemplated that hexavalent chromium would be reduced to the maximum extent possible before prohibited wastes are land disposed statement of Senator Chaffee, 130 Cong. Rec. Section 9178, July 25, 1984 . EPA thus does not view these data as representing BDAT, nor as minimizing threats to human health and the environment.

EPA also received comments requesting that the Agency clarify the appropriate treatment for characteristic metal wastes that are identified as slags, glass, concrete, bricks, and other inorganic solid debris. The commenters stated that these materials would probably have to be crushed or otherwise reduced in size prior to stabilization in order to comply with the D007 treatment standards. The Agency agrees that these, as well as other similar wastes, form a different treatability group and is identifying this group of D007 wastes as the "inorganic solids debris" treatability group. Wastes in this treatability group are defined in section 268.2(a)(7) of today's rule as follows: "nonfriable inorganic solids that are incapable of passing through a 9.5 mm standard sieve that require cutting, or crushing and grinding in mechanical sizing equipment prior to stabilization, limited to the following inorganic or metal materials: 1) metal slags (either dross or scoria); 2) glassified slag; 3) glass; 4) concrete (excluding cementitious or pozzolanic stabilized hazardous wastes); 5) masonry and refractory bricks; 6) metal cans, containers, drums, or tanks; 7) metal nuts, bolts, pipes, pumps, valves, appliances, or industrial equipment; and 8) scrap metal as defined in 40

261.1(c)(6)." (Note: The 9.5 mm requirement on sieve size is based on a similar requirement for pretreatment of samples that are to be analyzed using the TCLP. This size also approximates the size of small pebbles that are often incorporated into some forms of concrete.)

While the Agency is establishing a separate treatability group for D007 "inorganic solids debris," it is promulgating the same concentration-based treatment standards for these wastes as for D007 characteristic wastes. Thus, there are no separate treatment standards for inorganic solid debris D007 wastes appearing in today's rule. The Agency has determined, however, that there is a national capacity shortage for treatment of this treatability group. Therefore, the standards for D007 wastes do not apply to "inorganic solids debris" until May 8, 1992.

Several commenters objected to the proposal to regulate total chromium rather than hexavalent chromium in D007 and U032. They stated that EPA should regulate only hexavalent chromium since "EPA has recognized that only the hexavalent chromium presents a threat to humans and the environment...." The Agency is not persuaded by these arguments, maintaining that treatment of total chromium will provide the most effective regulation of hexavalent forms. These comments improperly characterize the Agency's position. Under Subtitle C, EPA regulates on a total chromium basis unless it is demonstrated that (1) the chromium is exclusively (or nearly exclusively) trivalent, (2) the chromium is generated from a process that uses only trivalent chromium, and (3) the waste is managed in nonoxidizing environments. See 40 CFR 261.4(b)(6)(i)(1980). To date, EPA is unaware of any generator submitting a demonstration to EPA stating that his waste meets the three criteria noted above. EPA is not reopening this long-settled issue in this rulemaking.

The data available to EPA show that a treatment standard of 4.3 mg/l, based on treatment data submitted to the Agency (by HWTC and CyanoKem), is probably achievable for D007 nonwastewaters. However, EPA recognizes the diversity of wastes that qualify as hazardous under the D007 classification. Because of this diversity, EPA has chosen to regulate D007 wastes (nonwastewaters and wastewaters) at the characteristic level of 5.0 mg/l. From examination of the comments and review of the treatment data submitted for D007 nonwastewaters, EPA believes that even the most difficult to treat D007 waste (with the exception of wastes in the inorganic solid debris treatability group) can be treated currently to this level.

Table 1-1 BDAT Treatment Standards for D007 Wastes

Constituent	Maximum for any single grab sample: Total composition (mg/l)	Maximum for any single grab sample: TCLP (mg/l)
Nonwastewaters		
Chromium (total)	Not applicable	5.0
Wastewaters		
Chromium (total)	5.0	Not applicable

Table 1-2 BDAT Treatment Standards for U032 Wastes

Constituent	Maximum for any single grab sample: Total composition (mg/l)	Maximum for any single grab sample: TCLP (mg/l)
Nonwastewaters		
Chromium (total)	Not applicable	0.094
Wastewaters		
Chromium (total)	0.32	Not applicable

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

As defined in 40 CFR 261.24, D007 wastes are those that exhibit the characteristic of TC Toxicity for chromium: in other words, D007 nonwastewaters that have a chromium concentration of greater than 5.0 mg/l, as measured by the Toxicity Characteristic Leaching Procedure, or wastewaters with a total chromium concentration of greater than 5.0 mg/l. Section 2.1 describes the industries believed to be affected by the land disposal restrictions for D007 wastes and describes the processes identified by EPA that may generate these wastes. Section 2.2 summarizes the available waste characterization data for these wastes. Section 2.3 uses the Agency's analysis of the sources of D007 wastes and waste composition to divide D007 wastes into waste treatability groups.

2.1 Industries Affected and Process Description

Chromium is used in industry as the metal and as various inorganic and organic chromium compounds. The major products containing chromium are chromium ore, alloys, chemicals, and the metal itself. The industries affected by the land disposal restrictions for D007 wastes are (1) the metallurgical industry, which produces chromium ferroalloys, metals, and other chromium-containing materials; (2) the chemical industry, which produces chromates, chromic acid, chromium pigments, and a wide range of chromium chemicals; and (3) the refractory industry, which produces chromite to make refractory bricks to line metallurgical furnaces. Processes in these industries that may generate chromium-containing wastes are discussed below.

2.1.1 Production of Chromium Chemicals and Pigments

A list of current manufacturers of the most common chromium compounds is provided in Table 2-1. All chromium metal and chromium compounds that are produced in the United States are derived from various grades of

Table 2-1 Current Manufacturers of Chromium Chemicals

Compound	Plant	Location
Chromic acid	American Chrome & Chemicals, Inc.	Corpus Christi, TX
	Occidental Petroleum Corporation; Occidental Chemical Corporation, subsidiary	Castle Hayne, NC
	Allied Corporation	Baltimore, MD
Chromium oxide	Ferro Corporation, Color Division	Toccoa, GA
	National Industrial Chemical Co.	Chicago, IL
	Pfizer Inc.	Easton, PA
Chromium sulfate	Blue Grass Chemical Specialties	New Albany, NY
	Wayne Chemical Corporation	Milwaukee, WI
Potassium chromate/ dichromate	The Procter & Gamble Company J.T. Baker, Inc., subsidiary	Phillipsburg, NJ
	Allied Corporation	Baltimore, MD
Sodium chromate/ dichromate	American Chrome & Chemicals, Inc.	Corpus Christi, TX
	Occidental Petroleum Corporation; Occidental Chemical Corporation, subsidiary	Castle Hayne, NC
	Allied Corporation	Baltimore, MD
Calcium chromate	Barium & Chemicals, Inc.	Steubenville, OH
	National Industrial Chemical Co.	Chicago, IL

Source: SRI 1989.

chromite ore. Chromite ores are generally classified according to the type of production process in which the chromite ore is eventually used. Metallurgical chromite refers to high chromium content chromite ore, chemical chromite refers to high iron content chromite ore, and refractory chromite refers to high aluminum/low chromium content chromite ore.

Chromic acid (CrO_3) is produced by mixing sulfuric acid with sodium dichromate dihydrate in a heavy-walled steel or cast-iron reactor, which is heated externally and stirred with an agitator. The resultant mixture of sodium chromate and sulfuric acid is heated to 197°C to melt the constituents, allowing the reactions to complete. These reactions proceed as follows:

$$Na_2SO_4 + Na_2Cr_2O_7 \cdot 2H_2O \rightarrow 2Na_2CrO_4 + H_2SO_4 + H_2O$$

$$Na_2CrO_4 + 2H_2SO_4 \rightarrow CrO_3 + H_2O + 2NaHSO_4$$

Upon cooling, the molten chromic acid separates from the sodium bisulfate byproduct. The molten chromic acid layer is tapped from the reactor and flaked on water-cooled rolls to produce the commercial product. Chromic acid is used extensively in the metal finishing industry for the production of chemical conversion coatings and in decorative and hard chromium electroplating operations.

Chromium oxide (Cr_2O_3) is produced by reduction of an alkali dichromate in a self-sustaining dry reaction by a reducing agent such as sulfur, carbon, starch, wood flour, or ammonium chloride. The mixture of dichromate and an excess of reducing agent is ignited in a reverbatory furnace or small kiln, transferred to leaching tanks (where reaction byproducts are removed), filtered, washed, dried, and pulverized. The reduction reaction, using carbon as the reducing agent, is as follows:

$$Na_2Cr_2O_7 + 3C \rightarrow Cr_2O_3 + Na_2O + 3CO$$

Chromic oxide is used in the manufacture of chromium metal and aluminum-chromium master alloys and in pigments that are used where chemical and heat resistance are required.

Chromic sulfate ($Cr_2(SO_4)_3$) is manufactured by the sulfur dioxide reduction of sodium dichromate in an acid-resistant tank. The reaction is as follows:

$$Na_2Cr_2O_7 + 3\ SO_2 \rightarrow Cr_2(SO_4)_3 + Na_2O$$

After reduction is complete, steam is bubbled through the solution to decompose any impurities and remove excess sulfur dioxide. Chromic sulfate is used in leather tanning liquors and in textile mordants and dyes.

Potassium dichromate is made by reacting sodium dichromate with an equivalent amount of potassium chloride in a crystallization process. Potassium chromate is prepared by the reaction of potassium dichromate and potassium hydroxide. The reactions are as follows:

$$Na_2Cr_2O_7 + 2\ KCl \rightarrow K_2Cr_2O_7 + 2\ NaCl$$
$$K_2Cr_2O_7 + 2\ KOH \rightarrow 2\ K_2CrO_4 + H_2O$$

Potassium dichromate is used as an analytical standard for laboratory use and in tanning, dyeing, pigment applications, and metal finishing.

Sodium chromate is manufactured by roasting a mixture of ground chromium ore, soda ash, and lime in a rotary kiln. The reaction occurring in the kiln is as follows:

$$4\ FeO{\bullet}Cr_2O_3 + 8\ Na_2CO_3 + 8\ CaO + 7\ O_2 \rightarrow 8\ Na_2CrO_4 + 8\ CaCO_3 + 2\ Fe_2O_3$$

The kiln roast is discharged through a cooler and leached. The leached calcine residue is recycled to the raw materials mixing station. The crude chromate liquor is added to hydrolyzing tanks at a pH of 9 to precipitate alumina impurities. Removal of the precipitate by filtration leaves a refined sodium chromate liquor.

Sodium dichromate is produced by treatment of sodium chromate liquor with sulfuric acid. The reaction is as follows:

$$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

The mixture is passed through an evaporator, where sodium dichromate liquor is evaporated and a sodium sulfate byproduct is precipitated. The purified and concentrated dichromate liquor is crystallized, put through a crystal centrifuge, and dried as the final sodium dichromate product. Almost all chromium compounds are produced using either sodium chromate or sodium dichromate as the primary feedstock material.

Calcium chromate is manufactured by a proprietary process as a specialty chemical product. Calcium chromate is used as an oxidizing agent in the production of ferrochromium and is used in the production of pigments and metal finishing compounds.

2.1.2 Uses of Chromium and Chromium Chemicals

Table 2-2 lists the major uses of chromium and its compounds.

Chromium consumption can be attributed to three primary user groups or industries: metallurgical, chemical, and refractory. Uses of chromium in the metallurgical industry include the production of stainless steels; full, low-alloy, and electrical steels; carbon steels; and other metallurgical products, which include cast irons and nonferrous alloys.

Table 2-2 U.S. Chromium Consumption by Product (%)

Metallurgical	71.4
Wrought stainless and heat-resisting steels	51.3
Tool steels	1.3
Wrought alloy steels	9.5
Cast alloy steels	3.1
Alloy cast irons	1.8
Nonferrous alloys	3.1
Other	1.3
Chemical	15.1
Pigments	4.0
Metal finishing	3.3
Leather tanning	2.4
Drilling muds	0.7
Wood treatment	0.9
Water treatment	0.9
Chemical manufacture	1.1
Textiles	0.4
Catalyst	<0.3
Other	1.1
Refractory	13.5
Chrome and chrome-magnesite	2.2
Magnesite-chrome brick	3.1
Granular chrome-bearing	6.0
Granular chromite	2.2

Source: Hartford 1978 and Westbrook 1978.

These chromium products are used primarily in the manufacture of transportation, electrical, and construction equipment; heavy machinery; and fabricated metal products. Chromium-containing listed wastes generated from the metallurgical industry include K061, K062, and F006. These wastes are discussed in the BDAT background documents for these waste codes (USEPA 1988b, 1988c, 1988d).

Chromium is used in the chemical industry for manufacturing a wide variety of chromium chemicals, of which sodium chromate and sodium dichromate are the most commercially significant and are produced in the largest volume. Other chromium compounds are manufactured using sodium chromate or dichromate as the primary feedstock material. The more important secondary chromium chemicals include chromic acid, potassium chromate and dichromate, basic chromic sulfate, and chromium pigments.

Chromic acid is used in chromium plating and for the production of chemical conversion coatings. In chromium plating, chromium is plated from solutions in which it is present as an anion onto various substrates such as steel, brass, aluminum, plastics, and zinc die castings. The deposition of chromium from chromic acid solutions provides the substrate with a decorative and corrosion-resistant surface. In chemical conversion coating, chromate conversion coatings are produced on metals by chemical or electrochemical treatment with mixtures of hexavalent chromium and other compounds. These treatments convert the metal surface to a layer containing a complex mixture of chromium compounds that will prevent oxidation and provide corrosion protection. These operations consume large quantities of chromic acid and generate waste electroplating and conversion coating solutions and sludges generated from wastewater treatment. Listed wastes associated with these operations are F006 and F019.

Potassium chromate and dichromate are used in metal finishing, in tanning compounds, and as raw materials in the production of chromate color pigments and corrosion-inhibiting pigments. Listed wastes associated with the production of chromium pigments are K002, K003, K004, K005, K006, K007, and K008.

Chromium sulfate ($Cr_2(SO_4)_3$) is used in leather tanning and textiles. In these applications, chromium is used for its ability to form stable complexes with proteins, cellulosic materials, dyestuffs, and various synthetic polymers.

Other uses of chromium compounds include the manufacture of metal corrosion inhibitors for circulating water systems and for wood preservation. The use of chromium compounds in wood preservation has been largely attributable to the excellent results achieved by chromated copper arsenate. The treated wood is free from bleeding, paintable, and of an attractive olive-green color.

Chromium is used in the refractory industry to produce chrome brick, chrome-magnesite brick, and other refractory materials to line furnaces, kilns, incinerators, and other high-temperature industrial equipment. Other industrial sectors consuming chromium refractory include glass manufacturing, nonferrous metals production, primary minerals smelting, and ceramics production.

All of the above uses of chromium generate a variety of chromium-containing nonwastewaters and wastewaters. Treatment of the wastewaters usually generates chromium-bearing nonwastewater residues.

2.2 Waste Characterization

The Agency has data from EPA's 1986 National Survey of Hazardous Waste Generators on the approximate composition of the types of D007

wastes currently generated. The nonwastewater forms of D007 are shown to contain from 5.0 to 700,000 parts per million chromium. Other BDAT list metals may also be present at concentrations as high a percent level. Most wastewaters contain very low levels of organics.

The wastewater forms of D007 are shown to contain from 5.0 to 10,000 parts per million chromium. Frequently, other metals are also present. In a few cases, organics may be present at concentrations up to 1 percent.

Most of the facilities reporting generation of D007 wastes were plants producing industrial inorganic chromium chemicals and pigments, chromium plating and polishing operations, aluminum conversion coating operations, wood-preserving facilities, and petroleum refineries. The wastes generated included plating solutions, stainless steel acid baths and rinses, chromium conversion coating process rinses, and wastewater treatment sludges from treatment of chromium-containing wastewaters.

2.3 Determination of Waste Treatability Groups

Characteristic wastes with the same waste code may be produced in different processes in one industry or in different industries and thus may have different waste characteristics and may not be treatable to similar concentrations using the same technology. In these instances, the Agency may subdivide waste codes into several treatability groups. This is done when the chemical forms of the wastes are very different and clearly require different treatments or combinations of treatments. For example, inorganic and organometallic compounds containing the same metals frequently require different types of treatment. Based on a careful review of the generation of D007 wastes and available waste characterization data from a variety of chromium-containing wastes, the Agency has determined that D007 nonwastewaters and wastewaters form two

separate treatability groups. Additionally, for D007 nonwastewaters, the Agency is establishing a separate treatability group inorganic solid debris as discussed in the introduction to this document.

The concentration of chromium in D007 wastes is dependent on the waste type and the particular production process from which the waste is generated. However, the D007 wastes identified by the Agency in Section 2.2 are expected to be treatable to similar levels by use of the same technologies. However, the Agency has received many comments indicating that D007 refractory bricks may require special consideration because of the physical and chemical nature of these bricks. Therefore, D007 refractory bricks may require additional methods of treatment (such as the pulverizing of the bricks) prior to other treatment technologies applicable to D007 wastes (discussed in Section 3 of this document).

All nonwastewater forms of D007 wastes for which EPA has characterization data have similar compositions in terms of waste characteristics that affect treatment performance for BDAT list metals. Specifically, D007 nonwastewaters are not expected to have high concentrations of organic compounds, which would have the most important effect on BDAT list metals treatment technologies for nonwastewaters. All wastewater forms of chromium are also expected to be treated to similar levels by the same technologies for the same reasons as discussed above for nonwastewaters.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

Section 2 established two treatability groups for nonwastewater forms of D007 and another treatability group for wastewater forms of D007 wastes. This section identifies the treatment technologies that are applicable to treatment of these wastes and determines which, if any, of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must treat the waste of concern or a similar waste. For detailed descriptions of the technologies applicable for these wastes, or for wastes judged to be similar, see EPA's Treatment Technology Background Document (USEPA 1989b.) To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or a similar waste. Technologies available only at pilot- and bench-scale operations are not considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

The technologies applicable for treatment of chromium-containing wastes are those that reduce the concentration of chromium in the treated residual and/or reduce the leachability of chromium in the treated residual.

3.1.1 Treatment Technologies for Nonwastewaters

Chromium-containing nonwastewaters are generated as inorganic solids and sludges, typically from treatment of wastewaters, or as ash or slag from thermal processes, such as incineration or metallurgical processes. The two technologies that the Agency has identified as applicable for

treatment of chromium-containing nonwastewaters are high-temperature metals recovery and stabilization. These technologies are described below.

(1) High-temperature metals recovery. The basic principle of operation for this technology is that metals are separated from a waste as pure metals or metal oxides through high-temperature thermal reduction processes that typically use carbon, limestone, and silica (sand) as raw materials. The carbon acts as a reducing agent and reacts with metal compounds in the waste to generate carbon dioxide and free metal. The silica and limestone serve as fluxing agents. Some metals volatilize and are captured by air pollution control devices (APCDs); others remain behind in the residual slag. This process separates some of the volatile metals, typically for reuse, and reduces the concentration of those volatile metals in the furnace residuals. Hence, the amount of waste that needs to be land disposed is reduced. Occasionally the furnace residuals, which are more concentrated in the less volatile metals, can be reused. This is the case with chromium, which is not relatively volatile compared to many other metals. High-temperature metals recovery technologies are discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

(2) Stabilization technologies. Stabilization treatment technologies are designed to reduce the leachability of metals in the treated waste compared to that in the untreated waste. These technologies involve mixing the waste with lime/fly ash mixtures, cement, concrete mixtures, or other formulations, both proprietary and nonproprietary. The binder/waste mixture normally sets into a solid mass, which can be land disposed. Stabilization technologies are discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

3.1.2 Treatment Technologies for Wastewaters

Chromium-containing wastewaters are generated from chromium plating and polishing operations, chemical manufacture, leather tanning, water treatment, or other uses of soluble chromium compounds. These wastewaters are typically generated as aqueous, acidic, inorganic solutions that may contain high concentrations of hexavalent chromium and other dissolved metals. The Agency has identified two technology trains applicable to treatment of chromium-containing wastewaters: (1) chromium reduction followed by chemical precipitation and filtration and (2) ion exchange. These technologies are described below.

(1) Chromium reduction/chemical precipitation/filtration. The basic principle of chromium reduction is to reduce the valence of chromium in solution from the hexavalent state (in the form of chromate or dichromate ions) to the trivalent state. Common reducing agents utilized include sulfur dioxide (SO_2), sodium sulfite ($Na_2S_2O_3$), and sodium metabisulfite ($Na_2S_2O_5$). The reduction reaction is usually accomplished at a pH ranging from 2 to 3. The typical reduction process, using sodium metabisulfite, proceeds as follows:

$$Na_2S_2O_5 + H_2O \rightarrow 2NaHSO_3$$

$$6NaHSO_3 + 4H_2CrO_4 + 3H_2SO_4 \rightarrow 2Cr_2(SO_4)_3 + 3Na_2SO_4 + 10H_2O$$

Chromium reduction technologies are discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

Chemical precipitation is used when dissolved metals are to be removed from solution. This technology can be applied to a wide range of wastewaters containing dissolved chromium and other metals. The underlying principle of chemical precipitation is that metals in

wastewater are removed by the addition of a treatment chemical that converts the dissolved metal to a metal precipitate. The precipitate settles out (and/or is filtered out) of solution, leaving a lower concentration of the dissolved metal present in the solution. The principal chemicals used to convert soluble metal compounds to the less soluble forms include hydrated lime ($Ca(OH)_2$), caustic soda (NaOH), sodium sulfide (Na_2S), and, to a lesser extent, soda ash (Na_2CO_3), ferrous sulfide (FeS), and several other chemicals, depending on the metal(s) to be removed.

In the treatment of wastewaters containing chromium, at the completion of the chromium reduction step, the trivalent chromium compounds are precipitated from solution as chromium hydroxide at a pH above 8. The insoluble trivalent chromium (in the form of chromium hydroxide) is then allowed to settle (and/or is filtered) from solution. Chemical precipitation is discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

(2) Ion exchange. This technology is applicable to treatment of wastewaters containing relatively low concentrations of dissolved chromium. The chromium must be in a soluble ionic form (Cr^{+3}, CrO_4^{-2}) in order to be removed by this technology. The waste is passed through a bed of ion exchange resin beads. The resin adsorbs the soluble ions, thus removing them from solution. Ion exchange produces both a wastewater residual (from regeneration of the ion exchange resin) and a nonwastewater residual (the spent ion exchange resin). The spent regenerant solutions (usually acid solutions) are more concentrated than the original untreated waste (though much lower in volume) and must be treated for chromium removal by chemical precipitation followed by filtration if the regenerant solution is not recyclable. Ion exchange is discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

3.2 Demonstrated Treatment Technologies

High-temperature metals recovery as applied to chromium is currently demonstrated at manufacturing facilities. Stabilization is demonstrated for many wastes containing chromium and other BDAT list metals, including F006 wastes generated from electroplating operations.

Chemical reduction and chemical precipitation are demonstrated technologies that have been in full-scale use for many years in the chemical and metals industries. In fact, effluent guidelines limitations for several segments of the inorganic chemicals industry that generate chromium-containing wastewaters are based on the use of chemical reduction and precipitation technologies (USEPA 1982). Ion exchange is also demonstrated at many metal finishing facilities to remove chromium from wastewater and, in many cases, to recover the removed chromium for reuse in the metal finishing process.

4. PERFORMANCE DATA

This section presents the data available to EPA on the performance of demonstrated technologies (as described in Section 3) in treating D007 wastes or similar wastes. These data are used elsewhere in this document for determining which technologies represent BDAT (Section 5) and for assessing an achievable D007 treatment standard (Section 6). Available performance data consist of full-scale demonstration data, as well as bench- and pilot-scale test data. EPA evaluates these data in accordance with BDAT methodology as explained the BDAT methology document (USEPA 1989a).

Performance data, to the extent that they are available to EPA, should include the untreated and treated waste concentrations for a given constituent, values of operating parameters that were measured at the time the waste was being treated, values of relevant design parameters for the treatment technology, and data on waste characteristics that affect the performance of the treatment technology.

Where data are not available on the treatment of the specific wastes of concern, the Agency may elect to transfer data on the treatment of a similar waste or wastes using a demonstrated technology. To transfer data from another waste category, EPA must find that the wastes for which treatment standards are being developed are no more difficult to treat (based on the waste characteristics that affect performance of the demonstrated treatment technology) than the treated wastes from which performance data are being transferred.

4.1 Performance Data for Nonwastewaters

Presented in this section are data collected by EPA and submitted to the Agency during the comment period on treatment of various D007

wastes. These data include performance data for one or more of the following technologies: chromium reduction, chemical precipitation, filtration, and stabilization.

The section also includes data on the treatment of F-code and K-code wastes containing chromium. These data include performance data for high-temperature metals recovery of K061 wastes; stabilization of F006 wastes; and chromium reduction followed by chemical precipitation, settling, filtering, and dewatering of solids of K062 wastes.

The Agency believes that the tested K061 was similar in waste characteristics to many D007 wastes (such as off-specification chromium chemicals and incinerator ash residues containing chromium). The available data show that chromium was present at significant (i.e., treatable) concentrations in the K061 wastes, which are from the primary production of steel in electric furnaces. For the proposed rulemaking, EPA believed that the F006 and K062 nonwastewaters were similar to D007 wastewater treatment sludges in terms of waste characteristics and chromium concentrations. (However, during the comment period, many comments were received stating that the K062 wastes were very different from some D007 waste streams.)

4.1.1 Performance Data for Treatment of D007 Wastes Submitted During the Comment Period

During the comment period, the Agency received treatment data from the following commenters:

CyanoKem Incorporated

CyanoKem submitted treatment data for treatment of D007 nonwastewaters by chromium reduction followed by precipitation, vacuum filtration, and stabilization. These data are presented in Table 4-1 at

the end of this section and are available in the RCRA docket (reference number LD12-00020). These data consisted of ten data points for the treated effluents. However, these data did not contain the corresponding untreated TCLP values that can be used to compare to those of the treated waste in order to determine the reduction of chromium leachability. Because of deficiencies in these data, they were not used to develop a treatment standard.

Hazardous Waste Treatment Council

The Hazardous Waste Treatment Council submitted stabilization treatment data for treatment of D007 nonwastewaters using different treatment additives, which are confidential business information (CBI). These treatment data are presented in Table 4-2. The complete data package is available in the RCRA docket (reference number LD12-00050). These data consisted of 42 data points for the treated effluents. The Agency reviewed these data for consideration of a treatment standard. Although the bulk of these data were deficient (i.e., they lacked untreated TCLP values: only ten data points had corresponding untreated and treated TCLP values), the Agency calculated an achievable treatment standard of 0.74 mg/l based on these ten data points. (See Appendix A.) However, because of the diversity of wastes that qualify as hazardous under the D007 classification, these data were not used to develop the D007 nonwastewater treatment standards.

PQ Corporation

PQ Corporation submitted treatment performance data for treatment of D007 refractory bricks. These data appear in their entirety in the RCRA docket (reference number LD12-00120). These data consisted of four data points (two for cement stabilization and two for glassification). These data did not provide any quality assurance/quality control (QA/QC)

information. Also, the two data points per technology were not sufficient for calculating a treatment standard because of extreme variability in the data (i.e., 8.5 mg/l and 70 mg/l for cement stabilization and 61 mg/l and 110 mg/l for glassification). Because of the extreme variability of these data, they were not used to develop treatment standards for D007 nonwasteswaters.

Chemical Manufactures Association

The Chemical Manufacturers Association submitted 52 data points for treatment of D007 spent metal catalyst pressed sludges treated by chromium reduction followed by lime and sulfide precipitation, and dewatering. These data appear in their entirety in the RCRA docket (reference number LD12-00187). These data did not provide any information for the untreated TCLP values; nor quality assurance/quality control (QA/QC) data or design and operating parameters. Therefore, these data were not used to develop treatment standards for D007 wastes.

Chemical Waste Management

Chemical Waste Management submitted laboratory data consisting of nine data points for treatment of various D007 waste matrices by stabilization using cement and ferrous sulfate, and stabilization using cement, ferrous sulfate and lime. These data are contained in the RCRA docket (reference number LD12-00159). There were questions as to whether these data were aggregate, and these data did not contain any QA/QC data. These data were reviewed, and because of the above-mentioned deficiencies they were not used to develop treatment standards.

ChemFix Technologies, Incorporated

ChemFix Technologies, Inc., submitted two data points for treatment of K048 incinerator waste residue containing chromium, treated by fixation with "ChemFix" with and without "Chemset" pretreatment reagents. These data are contained in the RCRA docket (reference number LD12-00073). These data did not provide any quality assurance/quality control (QA/QC) information, and more information is needed on the pretreatment reagent "Chemset." ChemFix Technologies, Inc., also presented one data point for treatment of D007. No untreated value or quality assurance/quality control (QA/QC) data were given for this data point. As a result, none of the data from ChemFix Technologies, Inc., were used to develop treatment standards for D007 wastes.

E.I. Du Pont De Nemours and Company

E.I. Du Pont submitted sludge analysis aggregate data summarizing 31 data points resulting from neutralization followed by precipitation with lime followed by filtration. These data provided only summary (i.e., aggregate) information for the treated effluent. No untreated waste data or quality assurance/quality control (QA/QC) information was provided. Therefore, a treatment standard was not developed based on the one aggregate data point. These data are available in the RCRA docket (reference number LD12-00189).

Collis Incorporated

Collis Incorporated submitted sludge analysis data summarizing the data over a 4-year period resulting from chromium reduction followed by precipitation with lime followed by dewatering. These data provided only summary (i.e., aggregate) information for the sludge analysis. They did not provide any untreated waste information or quality assurance/

quality control (QA/QC) data. As a result, the above-mentioned data were not used to develop the D007 nonwastewater treatment standard. These data are available in the RCRA docket (reference number LD12-00217).

TRICIL Environmental Services Incorporated

TRICIL Incorporated submitted 12 months of EP toxicity summary data from treatment consisting of blending, acidification, neutralization, metal precipitation, and dewatering. These summary data did not contain any untreated values or quality assurance/quality control (QA/QC) data. Therefore, these data were not used to develop a D007 nonwastewater treatment standard. These data are available in the RCRA docket (reference number LD12-00094).

U.S. Department of Energy (DOE)

U.S. DOE submitted laboratory solidification data for treatment of a synthetic D007 waste using cement and/or silicate and/or envirostone. These laboratory data did not contain quality assurance/quality control (QA/QC) data. Therefore, the Agency did not use these data to develop a treatment standard. These data are available in the RCRA docket (reference number LD12-00198).

4.1.2 Performance Data for High-Temperature Metals Recovery (Not Received During the Comment Period)

The Agency has nine data sets for treatment of K061 waste by high-temperature metals recovery. Tables 4-3 and 4-4 at the end of this section summarize the treatment performance data collected for high-temperature metals recovery for each of the nine data sets. Seven of the data sets represent data that the Agency collected on a rotary kiln unit (presented in Table 4-3); the other data were submitted by industry and include two data sets from plasma arc furnace treatment (see Table 4-4).

Table 4-3 presents total composition data for the untreated waste and total composition and TCLP leachate data for the treated nonwastewater residual, as well as design and operating data for each sample set. Table 4-4 presents total composition data for the untreated waste, treated nonwastewater and treated scrubber wastewater and TCLP leachate data for the treated nonwastewater. For each of these two data sets, there are no TCLP leachate data provided for the untreated waste that can be used to compare to that of the treated waste in order to determine the reduction of chromium leachability.

For high-temperature metals recovery, treatment performance is measured by the reduction in the concentration of metal constituents in treatment residuals, as compared to the untreated waste, and also by the reduction of the leachability of the metals in the residual as compared to that in the untreated wastes. However, the data available to EPA in Tables 4-3 and 4-4 are not sufficient to show applicability of high-temperature metals recovery to treat D007 nonwastewaters because it is not clear that the total chromium concentration in the residual or in the TCLP leachate from the residual is lower than that in the untreated waste. Consequently, treatment standards were not developed from these data.

4.1.3 Performance Data for Stabilization of Chromium-Containing Wastes (Not Received During the Comment Period)

The Agency has performance data for treatment of chromium-containing wastes using stabilization, as shown in Table 4-5. The data presented in Table 4-5 are performance data developed from stabilization of a variety of chromium-containing F006 wastes. These data sets present untreated waste total composition and TCLP data and treated waste TCLP data, and they were used in developing F006 treatment standards. (The data are discussed in detail in the F006 background document (USEPA 1988d).) The treatment data indicate that F006 wastes with untreated TCLP leachate concentrations

up to 360 mg/l can be treated to below the chromium characteristic level by well-designed and well-operated stabilization processes. (All wastes were treated to less than 1.21 mg/l in the TCLP leachate.)

4.1.4 Performance Data for Chromium Reduction Followed by Precipitation, Settling, Filtration, and Dewatering of the Solids (Not Received During the Comment Period)

The data presented in Table 4-6 are performance data from treatment of a K062 waste by a technology train consisting of chromium reduction followed by precipitation, settling, filtration, and dewatering of the solids. During the precipitation step, excess lime had been added, and therefore the treatment for nonwastewaters was essentially the same as stabilization. These performance data represent 11 data sets. Total chromium concentrations in the TCLP extracts of the nonwastewater residuals were all below the detection limit of 0.050 mg/l, with the exception of 0.068 mg/l in Sample Set #4.

4.2 Performance Data for Wastewaters

As discussed in Section 4.1.2, the Agency has 11 data sets for treatment of a K062 waste by chromium reduction followed by chemical precipitation and filtration. The wastewater residuals had total chromium concentrations ranging from 0.10 to 0.20 mg/l, which is well below the TC toxicity characteristic limit of 5.0 mg/l.

The Agency also received a set of data consisting of ten data points from CyanoKem Corporation, submitted during the comment period, for treatment of D007 waste by chromium reduction followed by precipitation, vacuum filtration, and stabilization. These ten data points did not contain any untreated values nor quality assurance/quality control (QA/QC) data. Further, it was not clear what treatment train these data represented. (The comment stated that these D007 wastewater data were not submitted for consideration of a treatment standard, but just for information purposes.)

Additional wastewater treatment data, primarily from EPA's Office of Water, have been analyzed for the development of concentration-based treatment standards for D007 and other wastewaters. Further information on these data, including the sources of the data and the treatment technologies used, can be found in the Final Best Demonstrated Available Technology Background Document for Organic U and P Wastes and Multi-source Leachate, Volumes A, B, and C (USEPA 1990).

Table 4-1 Treatment Performance Data for Chromium Reduction Followed by Precipitation, Vacuum Filtration, and Stabilization of D007 Nonwastewater

Sample number	Chromium concentration	
	Untreated concentration total chromium (mg/kg)	Treated concentration (mg/l)
1	17,450	0.10
2	465,000	0.28
3	16,300	0.07
4	1,000	0.02
5	70,000	0.21
6	160	0.10
7	198,500	0.33
8	6,015	0.13
9	69,500	0.25
10	190,100	0.10

Source: Cyanokem Corp., 1990. Treatment performance data submitted to EPA; reference number LD12-0020.

Table 4-2 Treatment Performance Data[a] for Stabilization of D007 Nonwastewater

Sample number	Load number[b]	Chromium concentration	
		Untreated concentration (TCLP) (mg/l)	Treated concentration (TCLP) (mg/l)
1	4497B	1.66	0.1200
2	4497B	1.66	0.0810
3	4467B	0.096	0.0610
4	4467B	0.096	0.0600
5	5404B	4.42	0.0100
6	5404B	4.42	0.0940
7	6319	0.106	0.0600
8	6319	0.106	0.0090
9	6377	122.0	0.1000
10	6377	122.0	0.2200

[a]The only data presented here from the HWTC's entire data package are those that have corresponding untreated and treated TCLP values Additional chromium data for treated chromium concentrations are presented in Appendix A of this background document. The complete data for chromium submitted by HWTC are also contained in the RCRA Docket: reference number LD12-00050 and LD12-00067.

[b]Description of waste per load number

4497B: Sodium fluoride/metal sludge from a metal forming and wastewater treatment plant in the aerospace industry.

4467B: Incinerator flyash from the aerospace industry.

5404B: Mixed metal chips from machining operations in the aerospace industry.

6319: Water filtration sludge from the manufacture of conduit piping.

6377: Petroleum refinery waste containing between 10 and 20 percent monoethylamine and the remainder being water.

Source: Hazardous Waste Treatment Council, 1990. Treatment performance data submitted to EPA; reference number LD12-00050.

Table 4-3 Treatment Performance Data for High-Temperature Metals Recovery of K061 Waste: Waelz Kiln

Sample set[a]	Chromium concentration		
	Untreated waste[b] (mg/kg)	Furnace residual (mg/kg)	Furnace residual TCLP (mg/l)
Sample Set #1	905	662	<0.080
Sample Set #2	959	741	0.103
Sample Set #3	1,190	748	<0.080
Sample Set #4	903	978	<0.080
Sample Set #5	803	205	<0.080
Sample Set #6	909	477	<0.080
Sample Set #7	1,080	476	<0.080

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown at the end of this table.

[b] Analysis prior to addition of lime, coke, etc.

Source: USEPA 1987a.

Table 4-3 (continued)

Waste Characteristics Affecting Performance[a]

Boiling Point (in increasing order) -

Mercury	356°C
Cadmium	765°C
Zinc	909°C
Lead	1760°C
Chromium	2672°C

Boiling Point of Metal - No low boiling point metals are present in concentrations that could impact product (recovered metal) purity and use.

Thermal Conductivity[b] - The thermal conductivity of K061 waste has been estimated to be approximately 28 Btu/hr-ft°F.

Design and Operating Data for Rotary Kiln High-Temperature Metals Recovery

Parameter	Nominal value[c]	Operating value						
		6/2/87			6/3/87			
		SS #1	SS #2	SS #3	SS #4	SS #5	SS #6	SS #7
Kiln temperature (°C)	700-800	760-840[d]	730-820[d]	740-840[d]	720-840[e]	800-1065[e]	575-740[e]	575-740[e]
Feed rate (ton/hr)		-	-	-	-	-	-	-
Rate of rotation (min/rev)		1.5	1.5	1.3	1.5	1.1	1.1	1.1
Zinc content (%)		-	-	-	-	-	-	-
Moisture content (%)		13.3	10.8	11.2	14.7	11.4	14.4	9.2
Carbon content (%)		-	-	-	-	-	-	-
Calcium/silica ratio		3.48	3.33	9.84	5.6	5.89	8.54	8.8

[a]The waste characteristics affecting performance for high-temperature metals recovery are relative volatility and the heat transfer characteristics of the waste. As the best approximate measure of the parameters, EPA is using boiling point and thermal conductivity.

[b]Thermal conductivity was calculated based on major constituents present in the waste and their respective thermal conductivities. This calculation can be found in the Administrative Record for K061.

[c]This system was built in the 1920s and was not originally designed for treatment of K061 waste. Nominal values were developed by the plant in lieu of design values.

[d]Values reflect those for kiln #2.

[e]Values reflect those for kiln #3.

- = This information is considered Confidential Business Information.

Source: USEPA 1987a.

Table 4-4 Treatment Performance Data for High-Temperature Metals Recovery of K061 Waste: Plasma Arc Reactor

Sample set	Chromium concentration: Untreated waste[a] (ppm)	Treated slag (ppm)	Treated slag TCLP (mg/l)	Treated wastewater (mg/l)
Sample Set #1 (Stainless Steel)	60,000-100,000	40,000-170,000	-	0.05-0.10
Sample Set #2 (Carbon Steel)	400-5,000	2,000-12,000	0.013	0.03-0.08

- = No data.

[a] For the untreated waste, EPA has values for ranges only. Data were not available on the specific untreated values that corresponded to the treated values.

Comments:

1. Data were not provided showing the specific operating conditions at the time the wastes were treated.

2. No data were provided on treatment characteristics that affect performance.

Source: SKF Plasmadust 1987.

Table 4-5 Treatment Performance Data for Stabilization of F006 Waste

Constituent	Concentration: Untreated waste Total (mg/kg)	Untreated waste TCLP (mg/l)	Treated waste - TCLP (mg/l) Binder-to-waste ratio[a] 0.2	0.5	1.0	1.5
Sample Set #1 (Source-unknown)						
Chromium	1,270	0.34	0.51	NR	NR	NR
Oil and grease[b]	1,520	-	-	-	-	-
TOC[b]	14,600	-	-	-	-	-
Sample Set #2 (Source-auto parts manufacturing)						
Chromium	755	0.76	0.40	0.39	NR	NR
Oil and grease	60	-	-	-	-	-
TOC	1,500	-	-	-	-	-
Sample Set #3 (Source-aircraft over-hauling facility)						
Chromium	716	0.43	0.08	0.20	NR	NR
Oil and grease	37,000	-	-	-	-	-
TOC	137,000	-	-	-	-	-
Sample Set #4 (Source-aerospace manufacturing-mixture of F006 & F007)						
Chromium	12.9	7.58	NR	NR	0.40	0.34
Oil and grease	3,870	-	-	-	-	-
TOC	8,280	-	-	-	-	-
Sample Set #5 (Source-zinc plating)						
Chromium	110	0.18	0.23	0.30	NR	NR
Oil and grease	1,150	-	-	-	-	-
TOC	21,200	-	-	-	-	-
Sample Set #6 (Source-unknown)						
Chromium	12,200	25.3	0.25	0.38	NR	NR
Oil and grease	20,300	-	-	-	-	-
TOC	28,600	-	-	-	-	-

Table 4-5 (continued)

Constituent	Concentration: Untreated waste Total (mg/kg)	Untreated waste TCLP (mg/l)	Treated waste - TCLP (mg/l) Binder-to-waste ratio[a] 0.2	0.5	1.0	1.5
Sample Set #7 (Source-small engine manufacturing)						
Chromium	3,100	38.7	0.21	0.76	NR	NR
Oil and grease	2,770	-	-	-	-	-
TOC	6,550	-	-	-	-	-
Sample Set #8 (Source-circuit board manufacturing[c])						
Chromium	42,900	360	3.0	1.21	NR	NR
Oil and grease	130	-	-	-	-	-
TOC	550	-	-	-	-	-
Sample Set #9 (Source-unknown)						
Chromium	47.9	0.04	0.10	0.20	NR	NR
Oil and grease	30	-	-	-	-	-
TOC	10,700	-	-	-	-	-
Sample Set #10 (Source-unknown)						
Chromium	644	0.01	0.03	0.21	NR	NR
Oil and grease	1,430	-	-	-	-	-
TOC	5,960	-	-	-	-	-

- = Not applicable.

NR = Results of tests at this binder-to-waste ratio were not reported.

[a]Binder-to-waste ratio = $\frac{\text{weight of binder material}}{\text{weight of waste}}$

[b]Oil and grease and total organic carbon (TOC) have been identified by EPA as waste characteristics that affect the performance of stabilization.

[c]Circuit board manufacturing waste is not in its entirety defined as F006; however, an integral part of the manufacturing operation is electroplating. Treatment residuals generated from treatment of these electroplating wastes are F006.

Source: CWM 1987.

Table 4-6 Treatment Performance Data for Treatment of a K062 Waste by Chromium Reduction Followed by Chemical Precipitation and Vacuum Filtration

Constituent	Concentration			
	Untreated waste (ppm)	Treated nonwastewater		Treated wastewater (ppm)
		Total (mg/kg)	TCLP (mg/l)	
Sample Set #1[a]				
Chromium (hexavalent)	893	1.43	--	0.011
Chromium (total)	2,581	7,300	<0.050	0.12
Sample Set #2[a]				
Chromium (hexavalent)	807	1.04	--	0.19
Chromium (total)	2,279	7,400	<0.050	0.12
Sample Set #3[a]				
Chromium (hexavalent)	775	b	--	b
Chromium (total)	1,990	4,000	<0.050	0.20
Sample Set #4[a]				
Chromium (hexavalent)	0.6	0.92	--	0.042
Chromium (total)	556	2,400	0.068	0.10
Sample Set #5[a]				
Chromium (hexavalent)	917	0.741	--	0.058
Chromium (total)	2,236	11,500	<0.050	0.11
Sample Set #6[a]				
Chromium (hexavalent)	734	1.78	--	b
Chromium (total)	2,548	10,000	<0.050	0.10
Sample Set #7[a]				
Chromium (hexavalent)	769	--	--	0.12
Chromium (total)	2,314	16,300	<0.050	0.12
Sample Set #8[a]				
Chromium (hexavalent)	0.13	0.116	--	<0.01
Chromium (total)	831	2,800	<0.050	0.15
Sample Set #9[a]				
Chromium (hexavalent)	0.07	b	--	0.041
Chromium (total)	939	3,400	<0.050	0.10

Table 4-6 (continued)

Constituent	Concentration: Untreated waste (ppm)	Concentration: Treated nonwastewater, Total (mg/kg)	Concentration: Treated nonwastewater, TCLP (mg/l)	Concentration: Treated wastewater (ppm)
Sample Set #10				
Chromium (hexavalent)	0.08	0.078	--	0.106
Chromium (total)	395	4,400	<0.050	0.12
Sample Set #11				
Chromium (hexavalent)	0.30	1.24	--	<0.01
Chromium (total)	617	2,100	<0.050	0.18

[a] Untreated waste composite of K062 along with other non-K062 waste streams.

[b] Color interference.

Design and Operating Data

Sample set no.	Operating value: pH[a]	Suspended solids (mg/l)	Dissolved solids (mg/l)	Oil and grease (mg/l)
1	9	<1-100	1,900-118,100	<0.2-6
2	9	<1-100	1,900-118,100	<0.2-6
3	10	<1-100	1,900-118,100	<0.2-6
4	9	<1-100	1,900-118,100	<0.2-6
5	8	<1-100	1,900-118,100	<0.2-6
6	8	<1-100	1,900-118,100	<0.2-6
7	9	<1-100	1,900-118,100	<0.2-6
8	9	<1-100	1,900-118,100	<0.2-6
9	10	<1-100	1,900-118,100	<0.2-6
10	9	<1-100	1,900-118,100	<0.2-6
11	9	<1-100	1,900-118,100	<0.2-6

[a] The pH design value is 8-10.

Source: USEPA 1986.

5. DETERMINATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the Agency's rationale for determining best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of D007.

To determine BDAT, the Agency examines all available performance data on technologies that are identified as demonstrated to determine (using statistical techniques if necessary) whether one or more of the technologies performs significantly better than the others. The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available, the technology must (1) be commercially available and (2) provide "substantial" treatment of the waste, as determined through evaluation of treatment performance data. In determining whether treatment is substantial, EPA may consider treatment performance data from a waste as difficult, or more difficult, to treat as the waste of concern. If the best technology is found to be not available, then the next best technology is evaluated, and so on.

5.1 Nonwastewaters

For D007 nonwastewaters EPA has treatment performance data for various D007 waste streams submitted during the comment period. These data (discussed in Section 4 of this document) represent substantial treatment of D007 nonwastewaters. These data show substantial treatment of D007 nonwastewaters containing up to 465,000 total chromium mg/kg in untreated waste.

The F006 stabilization data show that the chromium concentration was reduced from as much as 360 mg/l in the untreated waste TCLP extract to

less than 1.21 mg/l in the stabilized waste TCLP extract. The F006 wastes contained as much as 42,900 mg/kg of chromium and as much as 137,000 mg/kg of TOC. The K062 data show chromium TCLP extract levels ranging from <0.050 to 0.068 mg/l. Accuracy-adjustment results in a range of <0.074 to 0.10 mg/l. (A correction factor of 1.47 is applied to these data, as shown in Table B-8 of USEPA 1988e.) The accuracy-adjusted data are presented in Table B-1 in Appendix B of this document.

Further, the Agency has no data suggesting that other methods of chromium treatment in nonwastewaters can be universally applied successfully to all D007 wastes. The data on high-temperature metals recovery of K061 waste show that chromium is concentrated in the nonwastewater residual (slag) from these processes. However, EPA does not have data showing that all forms of D007 wastes would be amenable to treatment by this recovery technology (e.g., wastewater treatment sludges).

EPA reviewed all of the available treatment performance data for chromium and determined that the treatment train consisting of chromium reduction followed by chemical precipitation, settling, filtering, and dewatering of solids generates a nonwastewater that gives the lowest levels for chromium in the TCLP leachate. This technology is also commercially available and demonstrated. The Agency has thus determined that chromium reduction followed by chemical precipitation, settling, filtering, and dewatering of solids represent BDAT for D007 nonwastewaters.

5.2 Wastewaters

For wastewater forms of D007 wastes, EPA has data on treatment of a K062 wastewaters containing chromium and a variety of other metals. These wastes were treated by chromium reduction followed by chemical precipitation, settling, filtration, and dewatering of solids. The data

presented in Table 4-6 show that hexavalent chromium concentration was reduced from as high as 917 mg/l in the untreated waste to less than 0.19 mg/l in the treated wastewater; the total chromium concentration was reduced from as high as 2,581 mg/l in the untreated waste to less than 0.20 mg/l in the treated wastewater. Accuracy adjustment of these K062 treatment data is detailed in Table B-2 in Appendix B of this document.

The data base developed by EPA's Office of Water (see USEPA 1989d) also supplies data on the treatment of wastewaters containing chromium. The Agency has determined, however, that these data represent treatment of wastes less difficult to treat than some D007 wastewaters. Therefore, EPA has not considered these data in development of wastewater treatment standards for D007.

Ion exchange may reduce chromium concentrations to levels similar to or lower than those achieved by chemical precipitation. However, regeneration of ion exchange resin systems will generate a wastewater residual stream (see Section 3.1.2(3)) that, if not directly recyclable, will probably still require treatment by reduction, chemical precipitation, and filtration.

EPA reviewed all of the available treatment performance data for chromium and determined that the treatment train of chromium reduction followed by chemical precipitation, settling, filtering, and dewatering of solids results in the best treated levels for chromium in wastewaters. Because the above-mentioned technologies are commercially available and demonstrated, the Agency has determined that chromium reduction followed by chemical precipitation, settling, filtration, and dewatering of solids are BDAT for D007 wastewaters.

6. CALCULATION OF BDAT TREATMENT STANDARDS

In Section 5, the Agency chose the best demonstrated available technology (BDAT) for both nonwastewaters and wastewaters based on the treatment data available to the Agency. In this section, the promulgated BDAT treatment standards for D007 wastes are determined and presented. Chromium is selected as the only regulated constituent because it is the only constituent regularly expected to be found in D007. If D007 wastes are mixed with other listed or characteristic hazardous wastes and thus contain other constituents, other treatment standards would also apply.

The Agency typically bases treatment standards for regulated constituents on the performance of well-designed and well-operated BDAT treatment systems. These standards must account for analytical limitations in available performance data and must be adjusted for variabilities related to treatment, sampling, and analytical techniques and procedures.

BDAT standards are determined for each constituent by multiplying the arithmetic mean of accuracy-adjusted constituent concentrations detected in treated waste by a "variability factor" specific to each constituent for each treatment technology defined as BDAT. Variability factors account for normal variations in the performance of a particular technology over time. They are designed to reflect the 99th percentile level of performance that the technology achieves in commercial operation. (For more information on the principles of calculating variability factors, see EPA's publication Methodology for Developing BDAT Treatment Standards (USEPA 1989a).)

6.1 Nonwastewaters

The Agency has treatment performance data to indicate that D007 nonwastewaters can be treated to 0.094 mg/l TCLP based on the treatment of K062 nonwastewaters. However, the Agency received treatment performance data to indicate that this level may not be routinely achievable. Further, many commenters submitted treatment performance data indicating that all D007 wastes may not be able to achieve the proposed standard of 0.094 mg/l. Most of these data submittals were deficient in information (see Section 4) and could not have been used to promulgate D007 treatment standards. However, if they were used to develop standards, the standards would range from 0.12 to 900 mg/l (see Appendix A). Further, the Agency notes that D007 nonwastewater treatment standards derived from F006 data (a data set meeting all of the Agency's BDAT quality criteria) would be 5.2 mg/l. Hence, EPA is acknowledging the diversity of wastes that qualify as hazardous under the D007 classification. Because of this diversity, the Agency has chosen to regulate D007 nonwastewaters at the characteristic level of 5.0 mg/l in the TCLP leachate. EPA has no information and acceptable data meeting EPA's data quality requirements to indicate that even the most difficult to treat D007 nonwastewaters (except chromium wastes in the inorganic solid debris treatability group) cannot be treated to this level (see Table 6-1).

6.2 Wastewaters

Although the Agency has treatment performance data to indicate that D007 wastewaters can be treated to 0.32 mg/l based on the treatment of K062 wastewaters, EPA is acknowledging the diversity of wastes that qualify as hazardous under the D007 classification. Because of this

Table 6-1 BDAT Treatment Standards for D007 Wastes

Constituent	Wastewater	Nonwastewater	
	Total composition (mg/l)	Total composition (mg/l)	TCLP (mg/l)
Chromium	5.0	NA	5.0

NA - Not applicable.

diversity, the Agency has chosen to promulgate a treatment standard for D007 wastewaters at the characteristic level of 5.0 mg/l. EPA has no information or acceptable data meeting EPA's data quality requirements to indicate that even the most difficult to treat D007 wastewaters cannot be treated to this level (see Table 6-1).

7. U WASTE CODES

This section addresses regulation of the only U waste that is listed for chromium. This waste, calcium chromate, U032, is identified in 40 CFR 261.33 as "discarded commercial/chemical products, off-specification species, container residues, and spill residues thereof."

7.1 Industries Affected

Industries that may generate chromium-containing U032 wastes are the metallurgical industry, in the production of ferrochromium (chromium-iron) alloy; the chemical industry, in the production of pigments, oxidizing agents, corrosion inhibitors, and metal finishing compounds; and the battery manufacturing industry, in the production of high-temperature batteries.

7.2 Applicable and Demonstrated Best Treatment Technologies

Calcium chromate (U032) is slightly soluble in water and soluble in diluted acids. EPA believes that calcium chromate wastes are primarily generated by facilities involved in the manufacture of pigments and by metal finishing operations, because these facilities are the most likely users of calcium chromate. U032 wastewaters are expected to be similar in nature to K062 and other wastes generated from metal finishing operations in terms of the concentration of chromium in the untreated waste and other waste characteristics affecting treatment performance. Therefore, the Agency believes that chromium reduction followed by chemical precipitation, filtration of the precipitate, and stabilization of the nonwastewater residual solids is applicable and demonstrated to treat these wastes. EPA has no other data suggesting that other treatment technologies are applicable or demonstrated for U032 wastes.

7.3 Determination of Best Demonstrated Available Technology

Because chemical reduction followed by chemical precipitation and filtration is the only treatment train demonstrated for wastewaters similar to U032, it is also considered the "best" treatment (see Section 5).

Further, the chromium in calcium chromate is a soluble (in acid solutions) hexavalent chromium and is therefore readily reducible by the chromium reduction step that is part of the K062 waste treatment train. The Agency did not receive any treatment data for U032 wastes. Also, the Agency has no information to indicate that constituents present in U032 are likely to interfere with the reduction treatment of hexavalent chromium achieved in the treated mixture of K062 and EP toxic metal wastewater. Likewise, as discussed in Section 5, chromium reduction, followed by chemical precipitation, settling, filtration, and dewatering of solids, of the K062 waste is considered "best" for nonwastewater forms of U032.

Chromium reduction, followed by chemical precipitation, settling, and dewatering of solids, is shown to provide the best treatment of chromium in wastewaters and nonwastewaters (see Section 5). These technologies are also all demonstrated and commercially available. Therefore, these technologies are determined to be BDAT for U032 wastes.

7.4 Selection of Regulated Constituents

EPA is promulgating treatment standards for chromium in both wastewater and nonwastewater U032. Chromium is the only Appendix VIII constituent for which this waste is listed, and it is the only BDAT list constituent that the Agency expects to find in the waste on a regular basis (unless this waste is mixed with other listed hazardous wastes, in which case other treatment standards would also apply).

7.5 Development of Treatment Standards

Treatment standards for chromium in U032 wastes are based on chromium reduction and chemical precipitation followed by settling filtration and solids dewatering for wastewaters and nonwastewaters. Treatment standards for U032 are transferred from the performance of the BDATs for K062 waste. The calculations of the U032 treatment standards are shown in Tables 7-1 and 7-2 for nonwastewaters and wastewaters, respectively. The treatment standards for U032 are presented in Table 7-3.

Table 7-1 Calculation of U032 (Calcium Chromate) Nonwastewater Treatment Standards Using K062 Data

Regulated constituent	Accuracy-adjusted treated waste concentration[a] (mg/l) (1)	Mean treated waste concentration (mg/l) (2)	Variability factor (VF)[b] (3)	Treatment standard (total composition) (mg/l) (4) = (2) (3)
Chromium (total)	0.074	0.076	1.24	0.094
	0.074			
	0.074			
	0.10			
	0.074			
	0.074			
	0.074			
	0.074			
	0.074			
	0.074			
	0.074			
	0.074			

[a] From Appendix B.

[b] See Methodology Document (USEPA 1989a) for calculation of variability factor.

3339g

Table 7-2 Calculation of U032 (Calcium Chromate) Wastewater Treatment Standards Using KD62 Data

Regulated constituent	Accuracy-adjusted treated waste concentration[a] (mg/l) (1)	Mean treated waste concentration (mg/l) (2)	Variability factor (VF)[b] (3)	Treatment standard (total composition) (mg/l) (4) = (2) (3)
Chromium (total)	0.1765	0.1898	1.69	0.32
	0.1765			
	0.2941			
	0.1471			
	0.1471			
	0.1618			
	0.1471			
	0.1765			
	0.2206			
	0.1471			
	0.1765			
	0.2647			

[a] From Appendix B.

[b] See Methodology Document (USEPA 1989a) for calculation of variability factor.

Table 7-3 Treatment Standards for U032 (Calcium Chromate)

Constituent	Wastewater Total composition (mg/l)	Nonwastewater Total composition (mg/l)	Nonwastewater TCLP (mg/l)
Chromium (U032)	0.32	NA	0.094

NA - Not applicable.

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APPENDIX A

Calculation of Achievable D007 Treatment Standards
Based on
Data Submitted to the Agency during the Comment Period

CYANOKEM

(10 data points)

D007 nonwastewaters treated by chromium reduction followed by precipitation, vacuum filtration, and stabilization.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-2.085 + 2.33 (.8292))

TS = 0.86 ppm

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CYANOKEM	1.530E-01	1.018E-01	10	1.150E-01	2.000E-02	3.300
LN	-2.085	8.292E-01	10	-2.171	-3.912	-1.109

VIEW DATA

CASE	CYANOKEM	LN
1	0.1000	-2.3026
2	0.2800	-1.2730
3	0.0700	-2.6593
4	0.0200	-3.9120
5	0.2100	-1.5606
6	0.1000	-2.3026
7	0.3300	-1.1087
8	0.1300	-2.0402
9	0.2500	-1.3863
10	0.1000	-2.3026

HWTC

(10 data points)

Stabilization using proprietary reagents.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-2.693 + 2.33 x 1.028)

TS = 0.74 ppm

VIEW DATA

CASE	HWTC	CORRECTED	LN
1	0.1200	0.1411	-1.9583
2	0.0810	0.0952	-2.3518
3	0.0610	0.0718	-2.6344
4	0.0600	0.0706	-2.6510
5	0.0100	0.0118	-4.4431
6	0.0940	0.1106	-2.2020
7	0.0600	0.0706	-2.6521
8	0.0090	0.0106	-4.5488
9	0.1000	0.1176	-2.1405
10	0.2200	0.2588	-1.3516

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM
HWTC	8.150E-02	6.044E-02	10	7.100E-02	9.000E-03
CORRECTED	9.586E-02	7.110E-02	10	8.348E-02	1.058E-02
LN	-2.693	1.029	10	-2.493	-4.549

Cyanokem and HWTC
(20 data points)

Treatment Standard (TS)=exp (LN mean + Ln standard dev.)
TS= exp -2.389 + 2.33 (0.961)
TS= 0.86 ppm

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM
CYANO&HWTC	1.274E-01	9.139E-02	20	1.000E-01	1.060E-02
LN	-2.389	0.961	20	-2.303	-4.547

VIEW DATA

CASE	CYANOKEM	LN
1	0.1000	-2.3026
2	0.2800	-1.2730
3	0.0700	-2.6593
4	0.0200	-3.9120
5	0.2100	-1.5606
6	0.1000	-2.3026
7	0.3300	-1.1087
8	0.1300	-2.0402
9	0.2500	-1.3863
10	0.1000	-2.3026
11	0.1411	-1.9583
12	0.0952	-2.3518
13	0.0718	-2.6339
14	0.0706	-2.6507
15	0.0118	-4.4397
16	0.1106	-2.2018
17	0.0706	-2.6507
18	0.0106	-4.5469
19	0.1176	-2.1405
20	0.2588	-1.3517

HWTC and Cyanokem
(52 data points)

Treatment standard (TS) = exp (LN mean +2.33 LN standard deviation)

TS = exp (-2.043 + 2.33 (1.501))

= 4.3 ppm

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM
CHROME	1.548	9.201	51	8.100E-02	9.000E-03
CORRECTED	1.816	10.83	51	9.530E-02	1.060E-02
LN	2.043	1.501	51	-2.351	-4.547

VIEW DATA

CASE	CHROME	CORRECTED	LN	CASE	CHROME	[1](HWTC only) CORRECTED	LN
1	4.5400	5.3400	1.6752	26	0.0700	0.0823	-2.4
2	1.3800	1.6235	0.4846	27	0.0800	0.0941	-2.3
3	0.0800	0.0941	-2.3634	28	0.0520	0.0612	-2.7
4	0.0520	0.0612	-2.7936	29	0.1000	0.1176	-2.1
5	0.0100	0.0118	-4.4397	30	0.4210	0.4953	-0.7
6	0.0940	0.1106	-2.2018	31	0.1000	0.1176	-2.1
7	0.1200	0.1412	-1.9576	32	0.2200	0.2588	-1.3
8	0.0810	0.0953	-2.3507	33	0.3110	0.3658	-1.0
9	1.3600	1.6000	0.4700	34	0.1000	0.1176	-2.1
10	0.0800	0.0941	-2.3634	35	0.0610	0.0718	-2.6
11	0.0520	0.0612	-2.7936	36	0.0600	0.0706	-2.6
12	0.0520	0.0612	-2.7936	37	0.0600	0.0706	-2.6
13	0.0600	0.0706	-2.6507	38	0.0520	0.0612	-2.7
14	0.0800	0.0941	-2.3634	39	0.0800	0.0941	-2.3
15	0.0600	0.0706	-2.6507	40	0.1660	0.1953	-1.6
16	0.0090	0.0106	-4.5469	41	0.1000	0.1000	-2.3
17	0.0600	0.0706	-2.6507	42	0.2800	0.2800	-1.3
18	0.1830	0.2153	-1.5357	43	0.0700	0.0700	-2.6
19	0.0100	0.0118	-4.4397	45	0.2100	0.2100	-1.5
20	0.0520	0.0612	-2.7936	46	0.1000	0.1000	-2.3
21	0.2600	0.3058	-1.1848	47	0.3300	0.3300	-1.1
22	0.8210	0.9658	-0.0348	48	0.1300	0.1300	-2.0
23	0.0100	0.0118	-4.4397	49	0.2500	0.2500	-1.3
24	0.0520	0.0612	-2.7936	50	0.1000	0.1000	-2.3
25	0.0850	0.1000	-2.3026	51	65.800	77.411	4.3
				52	182(deleted as an outlier)		

1 corrected using 85% recovery cited in the text of the HWTC'S data submittal

cases 1-40 and 51-52 are HWTC'S data

cases 41-58 are CyanoKEMS'S data

COLLIS

(2 data points)

Sludge analysis data from treatment by chromium reduction followed by precipitation with lime followed by dewatering.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-0.7061 + 2.33 (1.208))

TS = 8.2 ppm

VIEW DATA

CASE	COLLIS	LNCOLLIS
1	0.2100	-1.5606
2	1.1600	0.1484

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
COLLIS	6.850E-01	6.718E-01	2	6.850E-01	2.100E-01	1.160
LNCOLLIS	-7.061E-01	1.208	2	-7.061E-01	-1.561	1.484E-01

PQ

(2 data points)

Cement stabilization treatment of refractory bricks.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-3.58 + 2.33 x 1.491)

TS = 1158 ppm

VIEW DATA

CASE	CEMENT	CORRECTED[1]	LN
1	8.5000	12.500	2.5257
2	70.000	102.90	4.6338

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CEMENT	39.25	43.49	2	39.25	8.500	70.00
CORRECTED	57.70	63.92	2	57.70	12.50	102.9
LN	3.580	1.491	2	3.580	2.525	4.634

[1] 68 percent recovery from F006 used to accuracy adjust data

PQ

(4 data points)

Cement stabilization and glassification treatment of refractory bricks.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-3.293 + 1.932 (2.33))

TS = 2427 ppm

VIEW DATA

CASE	REFRACTOR	CORRECTED	LN	ST
1	8.5000	12.500	2.5257	-0.7548
2	70.000	102.90	4.6338	0.4335
3	110.00	161.76	5.0861	1.2072
4	61.000	2.5257	0.9265	-0.8859

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
REFRACTOR	62.37	41.76	4	65.50	8.500	110.0
CORRECTED	69.32	76.07	4	57.70	2.526	161.8
LN	3.293	1.932	4	3.580	9.265E-01	5.086
ST	1.533E-12	1.000	4	-1.607E-01	-8.853E-01	1.207

CMA

(52 data points)

Treatment of D007 spent metal catalyst pressed sludges treated by chromium reduction followed by lime and sulfide precipitation and dewatering.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

$$TS = \exp(-1.349 + 2.33\ (1.855))$$

$$TS = 20\ ppm$$

CASE	CMA	LNCMA
1	0.0300	-3.5066
2	0.0600	-2.8134
3	0.1000	-2.3026
4	0.0100	-4.6052
5	4.8000	1.5686
6	2.5000	0.9163
7	0.0800	-2.5257
8	0.1600	-1.8326
9	0.2300	-1.4697
10	0.1100	-2.2073
11	0.0100	-4.6052
12	0.3600	-1.0217
13	0.0700	-2.6593
14	0.0100	-4.6052
15	17.000	2.8332
16	1.2000	0.1823
17	0.4500	-0.7985
18	0.8200	-0.1985
19	1.0000	0.0000
20	0.4800	-0.7340
21	0.7600	-0.2744
22	1.5000	0.4055
23	0.1000	-2.3026
24	0.1000	-2.3026
25	0.6000	-0.5108
26	0.1300	-2.0402
27	0.3400	-1.0788
28	0.2000	-1.6094
29	0.0700	-2.6593
30	0.3000	-1.2040
31	3.0000	1.0986
32	0.3000	-1.2040
33	0.1700	-1.7720
34	0.0600	-2.8134
35	0.4000	-0.9163
36	0.0400	-3.2189
37	0.0200	-3.9120
38	0.0300	-3.5066
39	2.5000	0.9163
40	0.1600	-1.8326
41	0.0100	-4.6052
42	0.6000	-0.5108
43	1.1000	0.0953
44	1.0000	0.0000
45	0.6400	-0.4463
46	0.9000	-0.1054
47	0.0100	-4.6052
48	0.0700	-2.6593
49	0.6400	-0.4463
50	1.0000	0.0000
51	10.400	2.3418
52	6.7000	1.9021

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CMA	1.218	2.877	52	3.000E-01	1.000E-02	17.00
LNCMA	-1.349	1.855	52	-1.204	-4.605	2.833

CHEMFIX

(1 data point)

from CHEMFIX Technologies

concentration = 0.12 ppm

Treatment standard (TS) = 0.12 x 2.8 = 0.336 ppm

when 2.8 = variability factor used when there is one data point

CHEMFIX

(2 data points for K048 incinerator waste residue containing chromium)

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-0.4338 + 2.33 (0.6134))

= 2.7 ppm

VIEW DATA

CASE	CONC	LNCONC
1	0.4200	-0.8675
2	1.0000	0.0000

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CONC	7.100E-01	4.101E-01	2	7.100E-01	4.200E-01	1.000
LNCONC	-4.338E-01	6.134E-01	2	-4.338E-01	-8.675E-01	0.000

TRICIL

(162 data points)

EP toxicity data from treatment by blending, acidification, neutralization, metal precipitation, and dewatering.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-0.2882 + 2.33 (1.78))

TS = 12 ppm

CASE	TRICIL	LNTRICIL
1	0.1000	-2.3026
2	0.1000	-2.3026
3	0.1000	-2.3026
4	0.1000	-2.3026
5	0.1000	-2.3026
6	0.1000	-2.3026
7	0.1000	-2.3026
8	0.1000	-2.3026
9	0.1000	-2.3026
10	0.1000	-2.3026
11	0.1000	-2.3026
12	0.1000	-2.3026
13	0.1000	-2.3026
14	0.1000	-2.3026
15	0.1000	-2.3026
16	0.1000	-2.3026
17	0.1000	-2.3026
18	0.1000	-2.3026
19	0.1000	-2.3026
20	0.1000	-2.3026
21	0.1000	-2.3026
22	0.1000	-2.3026
23	0.1000	-2.3026
24	0.1000	-2.3026
25	0.4200	-0.8675
26	0.3600	-1.0217
27	0.5200	-0.6539
28	0.2000	-1.6094
29	1.0000	0.0000
30	0.3600	-1.0217
31	1.3800	0.3221
32	2.9800	1.0919
33	0.8200	-0.1985
34	0.5000	-0.6931
35	1.3000	0.2624
36	1.1000	0.0953
37	4.7600	1.5602
38	4.6800	1.5433
39	0.4200	-0.8675
40	0.1000	-2.3026
41	4.5600	1.5173
42	0.3200	-1.1394
43	0.5000	-0.6931
44	2.7200	1.0006
45	3.5200	1.2585
46	3.8400	1.3455
47	1.4800	0.3920
48	0.6800	-0.3857
49	0.2000	-1.6094
50	0.4800	-0.7340
51	0.2800	-1.2730
52	1.1000	0.0953
53	0.8400	-0.1744
54	1.9400	0.6627
55	3.7400	1.3191
56	4.6000	1.5261
57	2.4000	0.8755
58	1.2000	0.1823
59	4.2200	1.4398
60	4.4600	1.4951
61	1.4200	0.3507
62	1.6400	0.4947
63	0.3200	-1.1394
64	0.8000	-0.2231
65	0.6000	-0.5108
66	0.5800	-0.5447
67	0.5800	-0.5447
68	2.7600	1.0152
69	0.9800	-0.0202
70	0.8000	-0.2231
71	0.6800	-0.3857
72	2.3400	0.8502
73	1.6000	0.4700
74	4.6600	1.5390
75	4.9200	1.5933
76	0.9000	-0.1054
77	1.0400	0.0392
78	0.5000	-0.6931
79	1.3000	0.2624
80	1.3200	0.2776
81	1.2600	0.2311
82	1.8600	0.6206
83	0.8600	-0.1508
84	1.0400	0.0392
85	0.9200	-0.0834
86	0.9800	-0.0202
87	0.4000	-0.9163
88	0.3800	-0.9676

TRICIL (continued)

89	2.1000	0.7419
90	0.9400	-0.0619
91	1.3600	0.3075
92	2.4600	0.9002
93	1.0600	0.0583
94	1.4800	0.3920
95	1.6800	0.5188
96	1.0000	0.0000
97	2.3800	0.8671
98	1.2800	0.2469
99	0.4800	-0.7340
100	0.2000	-1.6094
101	0.6000	-0.5108
102	2.2400	0.8065
103	0.7800	-0.2485
104	2.6800	0.9858
105	0.6800	-0.3857
106	0.2600	-1.3471
107	1.2400	0.2151
108	0.6600	-0.4155
109	0.7800	-0.2485
110	1.2600	0.2311
111	0.9600	-0.0408
112	0.3800	-0.9676
113	0.3600	-1.0217
114	3.1600	1.1506
115	0.9600	-0.0408
116	0.6000	-0.5108
117	0.2800	-1.2730
118	0.7800	-0.2485
119	0.2000	-1.6094
120	0.6000	-0.5108
121	2.0800	0.7324
122	2.7400	1.0080
123	4.1600	1.4255
124	4.6200	1.5304
125	2.1200	0.7514
126	1.8200	0.5988
127	1.4400	0.3646
128	1.8600	0.6206
129	0.4800	-0.7340
130	0.9600	-0.0408
131	0.2400	-1.4271
132	0.2800	-1.2730
133	2.0000	0.6931
134	0.5000	-0.6931
135	0.2800	-1.2730
136	0.7000	-0.3567
137	0.6400	-0.4463
138	2.2000	0.7885
139	2.5000	0.9163
140	4.1400	1.4207
141	0.2000	-1.6094
142	1.3400	0.2927
143	3.3400	1.2060
144	2.8000	1.0296
145	1.1800	0.1655
146	1.6600	0.5068
147	0.3600	-1.0217
148	3.0800	1.1249
149	0.7200	-0.3285
150	0.3200	-1.1394
151	0.5000	-0.6931
152	0.9400	-0.1744
153	0.6600	-0.4155
154	2.5000	0.9163
155	3.4000	1.2238
156	0.6400	-0.4463
157	4.8600	1.5810
158	2.2000	0.7885
159	0.3600	-1.0217
160	1.3200	0.2776
161	4.7000	1.5476
162	1.6800	0.5188

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
TRICIL	1.322	1.308	162	8.500E-01	1.000E-01	4.920
LNTRICIL	-2.882E-01	1.178	162	-1.626E-01	-2.303	1.593

WASTE MANAGEMENT INC. (WMI) CHEMICAL WASTE MANAGEMENT (CWM)

(14 data points*)

Laboratory data for stabilization of various D007 waste matrices.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp(-0.9173 + 2.33 (3.316))

TS = 900 ppm

*2 data points debited as they showed no treatment.

VIEW DATA

CASE	WASTEINC	LNWASTEIN
1	0.0800	-2.5257
2	0.1100	-2.2073
3	0.1800	-1.7148
4	0.2200	-1.5141
5	0.1200	-2.1203
6	6.3500	1.8485
7	2455.0	7.8059
8	0.0500	-2.9957
9	0.0500	-2.9957
10	0.0650	-2.7334
11	0.0850	-2.4651
12	0.0500	-2.9957
13	0.0600	-2.8134
14	98.000	4.5850

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
WASTEINC	182.9	654.5	14	9.750E-02	5.000E-02	2.455E+03
LNWASTEINC	-9.173E-01	3.316	14	-2.336	-2.996	7.806

DOE #1

(44 data points)

Laboratory solidification data for a synthetic D007 waste.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp(-2.418 + 2.33 (1.367))

TS = 270 ppm

CASE	CONC1	LNCONC1
1	2.0500	0.7178
2	6.8200	1.9199
3	2.8500	1.0473
4	3.5700	1.2726
5	5.0800	1.6253
6	7.2000	1.9741
7	18.400	2.9124
8	37.800	3.6323
9	3.2200	1.1694
10	2.7200	1.0006
11	4.4900	1.5019
12	3.9100	1.3635
13	29.000	3.3673
14	4.9700	1.6034
15	3.1100	1.1346
16	11.700	2.4596
17	62.600	4.1368
18	235.00	5.4596
19	15.300	2.7279
20	26.900	3.2921
21	10.000	2.3026
22	2.4000	0.8755
23	4.5000	1.5041
24	2.9000	1.0647
25	16.300	2.7912
26	4.9000	1.5892
27	6.9000	1.9315
28	18.400	2.9124
29	16.600	2.8094
30	56.100	4.0271
31	32.400	3.4782
32	79.000	4.3694
33	80.100	4.3833
34	1.0300	0.0296
35	1.4500	0.3716
36	1.3900	0.3293
37	5.5200	1.7084
38	72.100	4.2781
39	31.700	3.4563
40	6.7200	1.9051
41	54.600	4.0000
42	22.500	3.1135
43	38.800	3.6584
44	178.00	5.1818

DOE #1 (continued)

(44 data points)

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CONC1	27.98	45.63	44	8.600	1.030	235.0
LNCONC1	2.418	1.367	44	2.138	2.956E-02	5.460

D0E #2

(26 data points)

Laboratory solidification data for a synthetic D007 waste.

Treatment standard (TS) = exp (LN mean + 2.33 LN standard deviation)

TS = exp (-0.3218 + 2.33 (1.385))

TS = 18 ppm

CASE	CONC2	LNCONC2
1	0.4200	-0.8675
2	0.7300	-0.3147
3	0.0200	-3.9120
4	1.1000	0.0953
5	0.4100	-0.8916
6	0.1300	-2.0402
7	0.4100	-0.8916
8	3.3400	1.2060
9	4.0600	1.4012
10	2.0100	0.6981
11	5.2800	1.6639
12	3.0900	1.1282
13	0.4300	-0.8440
14	0.0900	-2.4079
15	0.5900	-0.5276
16	0.5300	-0.6349
17	0.3000	-1.2040
18	0.1200	-2.1203
19	1.1800	0.1655
20	3.3300	1.2030
21	1.9900	0.6881
22	0.3100	-1.1712
23	0.2700	-1.3093
24	3.6800	1.3029
25	2.5200	0.9243
26	1.3400	0.2927

DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
CONC2	1.449	1.497	26	6.600E-01	2.000E-02	5.280
LNCONC2	-3.218E-01	1.385	26	-4.212E-01	-3.912	1.664

APPENDIX B

Summary of Accuracy Adjustment of Treatment
Data for Chromium (Total) in Treated K062 Wastes
Used to Calculate the U032 Standard

Appendix B-1 Summary of Accuracy Adjustment of Treatment Data for Chromium (Total) in Treated K062 Nonwastewaters

	Untreated waste concentration Total (mg/kg)	Measured treated waste concentration TCLP (mg/l)	Percent recovery for matrix spike test	Accuracy-correction factor	Accuracy-adjusted TCLP leachate concentration (mg/l)
Sample Set No. 1	2,581	<0.050	68	1.47	0.074
Sample Set No. 2	2,279	<0.050	68	1.47	0.074
Sample Set No. 3	1,990	<0.050	68	1.47	0.074
Sample Set No. 4	556	<0.050	68	1.47	0.10
Sample Set No. 5	2,236	<0.050	68	1.47	0.074
Sample Set No. 6	2,548	<0.050	68	1.47	0.074
Sample Set No. 7	2,314	<0.050	68	1.47	0.074
Sample Set No. 8	831	<0.050	68	1.47	0.074
Sample Set No. 9	939	<0.050	68	1.47	0.074
Sample Set No. 10	385	<0.050	68	1.47	0.074
Sample Set No. 11	617	<0.050	68	1.47	0.074

Source: USEPA 1988c.

Table B-2 Summary of Accuracy Adjustment of Treatment Data for Chromium (Total) in Treated K062 Wastewaters

	Untreated waste concentration Total (mg/kg)	Measured treated waste concentration TCLP (mg/l)	Percent recovery for matrix spike test	Accuracy-correction factor	Accuracy-adjusted TCLP leachate concentration (mg/l)
Sample Set No. 1	2,581	0.12	68	1.47	0.1764
Sample Set No. 2	2,279	0.12	68	1.47	0.1764
Sample Set No. 3	1,990	0.20	68	1.47	0.294
Sample Set No. 4	556	0.10	68	1.47	0.147
Sample Set No. 5	2,236	0.11	68	1.47	0.162
Sample Set No. 6	2,548	0.10	68	1.47	0.147
Sample Set No. 7	2,314	0.12	68	1.47	0.1764
Sample Set No. 8	831	0.15	68	1.47	0.2205
Sample Set No. 9	939	0.10	68	1.47	0.147
Sample Set No. 10	395	0.12	68	1.47	0.1764
Sample Set No. 11	617	0.18	68	1.47	0.2646

Source: USEPA 1988c.